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System in the Year 2025: A Scenario Approach

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Abstract

Electric cars may significantly contribute to a reduction in external costs of urban transport; their introduction is however fraught with difficulties. This paper investigates by means of a scenario analysis which conditions have to be fulfilled for a successful introduction in the city of Amsterdam. First, a short introduction to Amsterdam is given, followed by an outline of the potential of and the problems inherent in the introduction of electric cars. Next, four scenarios are constructed by means of the so-called Spider-model. This model has four major policy dimensions. It is visuaiized by a picture which consists of four quadrants and eight axes on which important future developments are sketched on a five point scale. The four quadrants represent policy concerns about the (inter)national flanking policies, local economic developments, local spatial policies and public transport policies, respectively. Four scenarios are next constructed: 'Prosperous Amsterdam', 'Sustainable Amsterdam', 'Pauperized Amsterdam' and 'Lonely Amsterdam'. These scenarios differ largely in economic developments and in the local and (inter)national focus on sustainability issues. Finally, the transport system and the potential role of the electric car in each scenario is investigated. It is concluded that flanking policies at both the (inter)national and local level as well as a positive economic development are a *sine qua* non for a successful introduction and adoption of the electric car. When these conditions are fulfilled, the electric car may decisively contribute to the achievement of a more environmental friendly urban transport-system.

1 A Sketch of Amsterdam

Amsterdam has in general similar problems as many other bigger cities in Europe: high unemployment levels, large and increasing congestion levels, lack of space and many related environmental problems. On the other hand, the city is going through a relatively dynamic development stage. Schiphol Amsterdam airport is growing rapidly and the services sector is developing very positively. The inner city has a high cultural value, which attracts many tourists from all over the world. The future general objectives of Amsterdam's municipality are that the city should become (Gemeenteblad, 1993):

* an **open city;** this holds for economic activities, immigrants, visitors, etc.
* a **sustainable city;** the development of the city should occur in a way in which the environment is saved to the maximum extent;
* an **international city;** especially the development of Schiphol, the harbour and top office locations are important in this respect;
* a **compact** city; suburbanization should be avoided and new residential areas should be planned in and around the city. This may result in lower mobility levels and an increase in public transport use (Nijkamp and Rienstra, 1996).

The population is relatively young and is growing more rapidly than the national average. It is expected that the population growth will continue rapidly, and several new residential areas are planned in and around the current built environment. The population growth in the Amsterdam region (ROA) is expected to grow from I. 3 mln in 1992 to 1.65-l. 8 mln in the year 2015. The population in the city itself may increase by 150.000 to 200.000 people (O+S/-DRO, 1993 and 1994).

The economic policy of Amsterdam has three main focal points. First. the national airport Schiphol should grow rapidly and become an international mainport and the fourth largest airport in Europe. Therefore the airport and the infrastructure around the airport will be expanded, while also airport related activities will grow rapidly. Secondly, the harbour area in the northwest of Amsterdam should expand and attract new industrial activities. Thirdly, the south of Amsterdam should become a top office location for services sectors, with a focus on national and international financial and business oriented companies (Bruinsma et al., 1997).

It is clear that the future transport policy of Amsterdam is facing many challenges. The economic and population growth has to be accommodated, while at the same time the environmental impacts of the transport system should be reduced. This paper investigates the potential role of the electric car in achieving these objectives, by applying a scenario analysis. The paper is based on Rienstra (1996).

The contents of the paper is as follows. First, a short introduction to the transport policy of Amsterdam and the potential of the electric car is given in Section 2. In Section 3, the model used for constructing the scenarios is presented, followed in Section 4 by the four scenarios and the potential role of the electric car in these scenarios. Finally, in Section 5, some conclusions are drawn.

2 The Potential Role of the Electric Car in Amsterdam's Transport Policy

Amsterdam s transport policy

In the past decades, Amsterdam's transport system has been developed by means of road infrastructure expansion, the construction of tram tracks and more recently underground and rapid tram systems. A characteristic of the urban transport system is the high level of bicycle use (Pharoah and Apel, 1995). Car ownership levels in Amsterdam are far below the national average, but car use is still rapidly rising. At the same time, public transport use is decreasing slightly. In the centre and older living quarters parking tariffs are introduced everywhere, while the road capacity in the centre has been reduced (ROA, 1993).

In the centre of Amsterdam a license is compulsory for driving a truck with a capacity exceeding 7.5 tons. Central city distribution centres at the city border are under discussion, in which large trucks should split up there freight. In this way freights for one customer can be combined and brought to the customer by smaller vans. Whether these centres will really come into being is yet uncertain.

The official national target for car mobility increase in the Dutch Randstad (the densely populated Western part of the Netherlands) is a growth of 20% between the years 1986 and 2010. Because this growth was already achieved in 1991, the official target is a stabilization of car use until the year 2010. An additional objective is the stimulation of public transport (e.g., by large scale investments in metro, rapid tram and light rail infrastructure) and of bicycle use.

In order to investigate whether and how these objectives can be achieved, three scenarios for the year 2005 are composed by the regional transport authority (ROA, 1993). Without additional measures car use is expected to increase by 40%. In the **base scenario** the parking fees are somewhat increased, the number of parking places is somewhat decreased, the road infrastructure will be expanded significantly and the local public transport infrastructure will be expanded according to current plans [1].

In **the national policy scenario** additional measures are assumed, which are official national policy measures (Tweede Kamer, 1990). This includes the introduction of a 'rush hour fee' for cars, higher parking fees and less parking places and a limited expansion of the road infrastructure network.

In the **objectives scenario** measures are taken which are assumed to be feasible. In an earlier stage an even more stringent scenario was constructed, but this was not regarded as socially and politically acceptable. The measures taken in this scenario are a higher rush hour fee, a more strict parking policy, the construction of a regional light rail system in cooperation with the Dutch Railways and a further expansion of high quality public transport infrastructure. The results of these scenarios in terms of mobility levels and modal split are presented in Figure 1 and Figure 2.

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[1] The main projects are the construction of an orbital 'rapid' tram way, a 'rapid' bus line towards Schiphol and Haarlem ('Zuid-tangent'), the North-South underground track and IJ-rail towards the new suburb 'IJburg'.

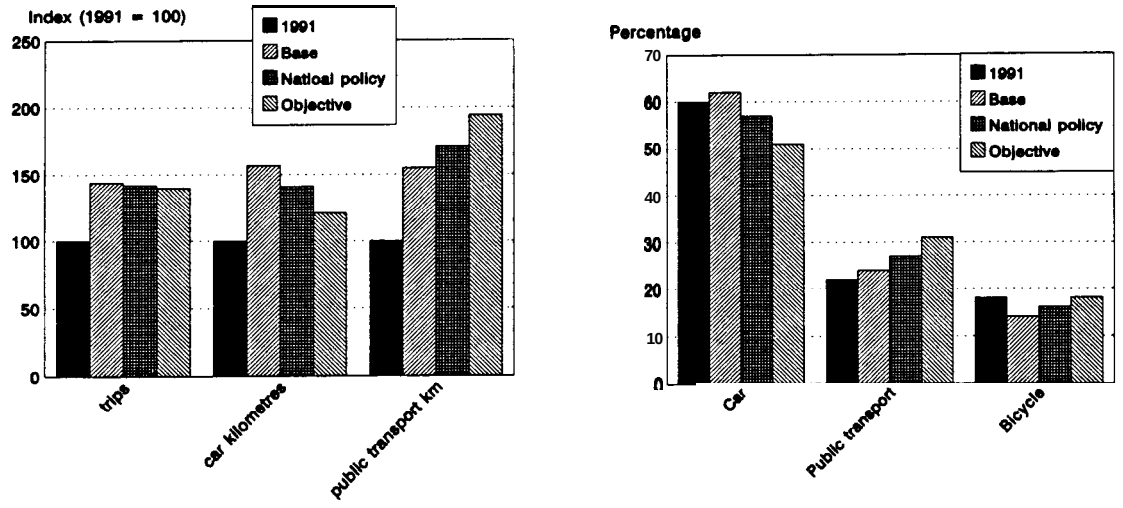

Figure 1 Development of the mobility level and the modal split in three ROA-scenarios
Source: ROA, 1993.

It appears that the zero-growth objective for car use is not feasible. Even in the most strict scenario, car use will grow by 20%. In this scenario public transport use will double. Another interesting finding is that bicycle use is not expected to grow significantly, despite the reduction of car mobility.

It is however questionable, whether these scenarios can be achieved. A rush hour fee or another type of road pricing is still under discussion and has been postponed several times, while there is also quite some resistance against the local parking policy. As a result, car use may increase and the emission reduction targets may not be achieved. An alternative policy option - which does not get much attention in local policy debates - may be the substitution of the conventional car by the electric car. This will be discussed next.

Characteristics of electric cars

Electric cars have - compared to conventional cars - some important environmental **advantages** (DeLuchi, 1993; Novem, 1992):

* at the local level there are no emissions of harmful gasses;
* there is no noise annoyance;
* at the macro level the emissions of greenhouse gases are lower; in the Netherlands for example, the CO_2 emissions are about 20% lower than of conventional cars, but this percentage is very much depending on the way electricity is produced and it differs therefore very much per country.

In the long term these advantages may even increase (OECD, 1992): it is easier and cheaper to decrease emissions of power plants than of millions of mobile sources (also because of future more sustainable ways of producing electricity like wind and sun energy), electric cars can more easily drive subterranean, hybrid applications may be feasible and the dependence on oil producing countries can be reduced. An environmental problem of electric cars are the batteries, although recycling possibilities may largely increase in the future.

The main **disadvantages** of electric cars are the technical specifications (see for an extensive overview Quandt, 1995). The most important problem is the low action radius of the car in combination with long charging times (8 hours). Nowadays this is at maximum 130 kilometres, in the year 2010 this may increase to 200 kilometres. Although most cars only incidentally exceed this spatial range, the 'option value' of longer ranges forms a major obstacle for potential consumers. Also the acceleration power and the speed are less important problems, which may be largely solved in coming decades (European Commission, 1996).

A second obstacle is the costs of electric cars. At the moment these are higher than those of conventional cars. However, when mass production is realized the price of electric cars may be as high as that of conventional cars; in this respect, assumptions about the future fuel and electricity prices and the costs of the batteries are extremely important (DeLuchi et al., 1989; Novem, 1992).

It can be concluded that the main problem of electric cars is the low geographical range. This problem is not likely to be solved. Additional policy measures may therefore be necessary to successfully introduce the electric car. An important concern however is that the introduction will not result in higher mobility - and congestion - levels. The low variable costs of electricity and high fixed costs of the electric car (batteries) may therefore cause problems.

In the next sections we will now analyze the potential of electric cars by means of a scenario analysis. First, the model used will be discussed in Section 3, after which the scenarios will be constructed.

3 The Spider Model for Depicting the Future of Amsterdam

The scenario analysis will be carried out by means of an adapted version of the so-called Spider model. This model has been applied in an earlier study to depict the future of the European transport system. The model used is presented in Figure 2.

The Spider web is subdivided in four main fields, which represent the major developments and policy objectives, which are also concisely discussed in Sections 1 and 2. The eight axes represent the most important driving forces within these fields. The outer points on the axes can be regarded as 'desirable' developments, as they are defined in the local policy or for achieving a sustainable economic development. The points on the axes in the middle of the model on the other hand, present more or less undesirable developments. Next, we will shortly discuss the contents of the quadrants and axes in more detail.

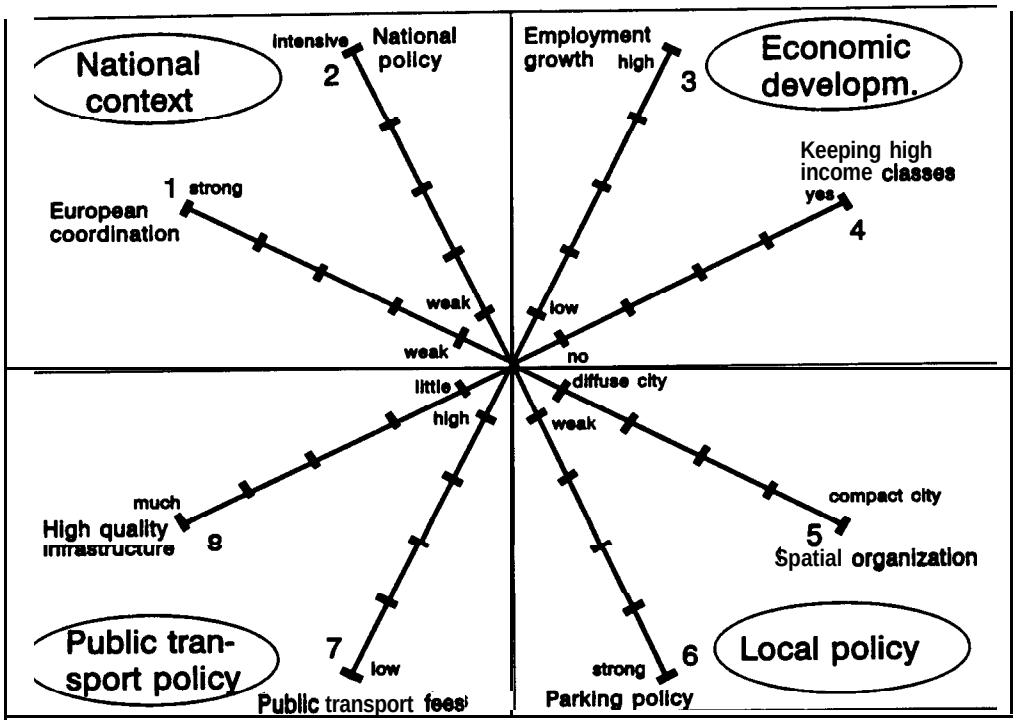

Figure 2 The Spider model ***for*** *depicting the future* ***of*** *Amsterdam*

Quadrant 1: the national context

For analyzing the future of the local and regional transport system, it is first important to know which measures are taken at the (inter)national level. Policies at this level determine to a large extent the prices of mobility, while also other measures may be introduced which influence the future of transport and the modal split.

On axis 1 the European coordination of the environmental and transport policy is presented. The economies of EU members are then supposed to be increasingly integrated, which may reduce possibilities to protect sectors (e.g., public transport companies). Because more sectors are subject to international competition, environmental measures may influence the national economy, because activities shift to other countries or consumers may purchase goods in other countries (e.g., fuel prices, CO_2 tax). European coordination may also be important for advantages of scale in R & D and the production of new technologies (Rienstra and Nijkamp, 1997).

Also the national transport policy (axis 2) has a large impact. Ownership taxes largely influence the prices of cars, while also measures like road pricing and fuel taxes may largely influence the mobility level and the modal split. Also the prices, subsidies and investments in public transport infrastructure and distinct types of infrastructure are largely determined by national policies.

Quadrant 2: Local-economic developments

In the second quadrant of the Spider web, the most important local economic policy objectives are depicted. In the first place stimulating employment is found (axis 3), which is one of the major objectives at all authority levels. Partly, local policies may influence this, although also (inter)national trends are of major importance for the (un)employment rates.

On the next axis (4) the social economic structure of the population is presented by means of the share of the population in the higher income classes. In past decades, this group has largely left the city because of the low quality and quantity of houses and the detoriation of neighbourhoods. Lower income classes are left behind, which had a negative impact on the economic and social carrying capacity of the city. Achieving a trend breach in this field is an important policy objective therefore.

Quadrant 3: local policies

Several issues influencing the future of transport can also be explicitly influenced by the local government. On axis 5 we find the spatial policy. As already discussed above, achieving a compact city is at the moment a major policy objective, which influences the planning of new residential areas, the living climate and the spatial economic structure and the modal split.

On the next axis (6) we find the parking policy, which has proven to be one of the most important policies to reduce car use in cities. This relates both to the reduction of parking places and parking fees.

Quadrant 4: the public transport policy

At all authority levels, stimulating public transport use is an important policy objective. Therefore, the future public transport policy will largely influence the future of the urban transport system. In the first place, the level of public transport fares (axis 7) is important. These determine- - in combination with road pricing systems and fuel taxes - the competitive position of the public transport system, as well as the profitability of the system.

Secondly, investments in high quality public transport infrastructure will stimulate public transport use. This relates to underground and light rail systems, but also free and innovative bus lanes may be included in the score on this axis. In this way the efficiency and the attractiveness of the public transport system can largely be influenced.

The construction of the scenarios

Scenarios can now be constructed by combining points on each axis. Each axis is subdivided into five points; the inner and outer points are presenting extreme developments, while the inner points present more moderate developments. In this way the most important future developments and background factors influencing the future of the urban transport system can be determined; other developments can be deduced by means of logical reasoning.

It should be acknowledged that although the outer points contribute most to the achievement of policy and sustainable development objectives, the size of the

surface in the Spider web has no meaning for the degree of attractiveness of the scenario. The information on the axes is only qualitative; therefore, the scores on the axes cannot be compared, while also the order of the axes influences the size of the area. For a more detailed discussion of the Spider methodology we refer to Nijkamp et al. (1997a and 1997b).

In principle the developments on the distinct axes are independent, so that points can be combined at random. Of course, several combinations will present a more interesting and relevant future image than others.

In this model it is assumed that the urban transport system - and the role of the electric car - depends on the developments of trends on the axes. Therefore, first the general developments and the resulting transport system will be described in general; then the (potential) role of the electric car will be elaborated.

The choice of the scenarios

It is clear that within the Spider model thousands of scenarios can be constructed on the basis of combinational logic; therefore a choice has to be made. A first criterion may be that the 'scores' on the distinct axes differ, so that clearly different future images come into being. This will result in clear insights in the factors influencing the future of the electric car.

Second, it is meaningful to use existing scenarios and policy documents to some extent, in order to make the scenarios more policy relevant and to combine visions of other institutes. Therefore, for the national context quadrant recent scenarios of the Dutch Planning Bureau (CPB, 1996) have been (partly) used to identify different policy packages. This study describes measures which can be introduced in certain regimes of European coordination and national acceptance of measures (both low and high). These scenarios are concisely presented in this study, as well as quantitative indications of congestion and emission levels in each scenario:

* the **base scenario;** no additional measures are taken beyond current plans (including road pricing in rush hours) and fuel taxes remain constant (in real terms) ;
* **limited social support scenario;** measures are taken which will not cause much resistance, like lowering public transport fees, speed control, stimulating car pooling and changing ownership taxes;
* **national policy scenario;** measures are taken at the national level, without European coordination, and therefore sectors facing international competition are not harmed very much. Measures are: additional increases in fuel taxes (excluding diesel), high road pricing fees, measures to reduce business traffic and a policy aiming at spatial concentration;
* **European policy scenario;** measures are introduced all over Europe, giving governments more degrees of freedom. Measures in this scenario are: high emission standards, very high fuel taxes (including diesel), while other national policy measures are introduced much more strictly.

These scenarios will be linked to some extent to scenarios of municipal departments. The department of Economic Affairs (EZ, 1996) presents scenarios with possible economic developments of Amsterdam, based on regional cooperation or competition and major economic shifts in Europe. In addition, the environment department (Milieudienst, 1994) describes Amsterdam as a more or less sustainable city in which many spatial (compact city), environmental and transport measures are to be taken. These local scenarios are interpreted in a rather 'free' way in the scenarios constructed in this paper.

Next, many more assumptions and more explicit choices will be made in order to investigate the impacts on the transport system and the electric car. In this way four scenarios will be constructed in the next section: Prosperous Amsterdam, Sustainable Amsterdam, Pauperized Amsterdam and Lonely Amsterdam; the reference year for the scenarios is 2015.

In this way the scenarios test for certain degrees of freedom for the local government, while also the influence of several economic developments is analyzed. In the next section, these scenarios will be constructed.

4 Scenarios for the Future of Amsterdam's Transport System

4.1 Prosperous Amsterdam

In the scenario 'Prosperous Amsterdam' the policy at all authority levels aims at stimulating economic growth; transport is mainly seen as a system necessary for accommodating economic growth, and therefore no restrictive measures are taken. In the national context, the CPB base scenario is taken as starting point. At the same time it is assumed that the local and regional economy develops very positively, while the compact city policy is abolished. This results in scores on the distinct axes as presented in Figure 3. The scores on the axes will now be elaborated further, after which the role of the electric car will be discussed. These scores will be justified in an interpretative, indicative way by plausible reasoning regarding the scenarios. We will now offer an imaginary description of this scenario.

The national context

The national economy will develop positively: the competitive position of Europe and the Netherlands will largely improve and employment will greatly increase. The social acceptance of environmental and transport measures will be very limited, while there will also be little European coordination. Therefore, the measures as discussed in Section 2 will be implemented, while the taxes on conventional fuels remain constant (in real terms). This will result in a large mobility growth, while the use of public transport will be lower.

The High Speed Train will be constructed and the rail infrastructure will largely be expanded. At the same time, there will be an increasing pressure for public transport companies to work more efficient and profitable. This will result in a closing down of several tracks and to a reduction of frequencies. As a result, public transport will not be very attractive for longer distance trips.

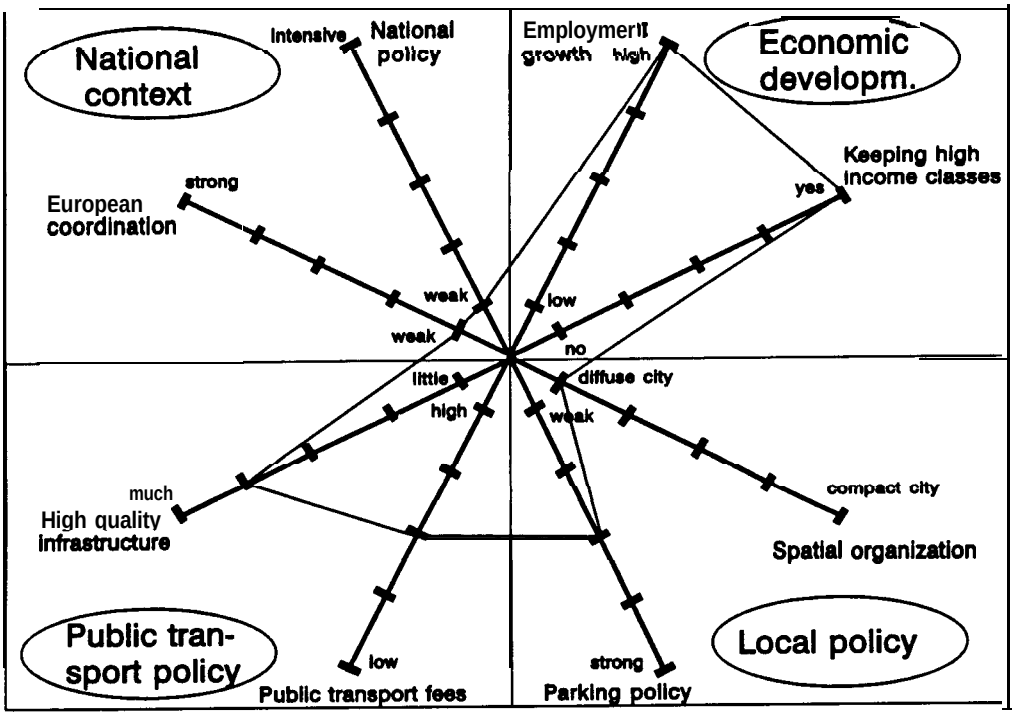

Figure 3 The scores in the scenario 'Prosperous Amsterdam '

Local economic developments

As mentioned above, the (inter)national economy will develop very positively. At the same time there will be a strong coordination within the larger Amsterdam region, which will make the region an attractive location for companies. As a result, the economy and employment within the region will develop very positively.

Schiphol airport will become an international mainport, which will stimulate the economic developments in the rest of Amsterdam. The same holds for the Amsterdam harbour, which will attract many new activities. Especially in these areas the employment and economic activities will largely expand, although this results in large emissions of gases by airplanes, while there is also an increasing noise and stench annoyance.

Also the services sector (especially the national and international oriented sectors) will strongly develop. At the South of Amsterdam an international competing location will be developed, which is well connected by the underground with the centre of the city and by light rail systems and a highway with Schiphol Airport. Also other office locations will develop strongly and will attract many activities.

The local economic policy will aim at stimulating economic activities to the maximum extent, amongst others by means of tax cuts. But also other restrictive measures are not implemented; e.g., central goods distribution centre will not be introduced.

Amsterdam will succeed in offering higher income classes attractive housing and employment possibilities. As a result, the socio-economic carrying capacity within the city will improve. All these trends will result in an increasing pressure on space and environment.

Local policy

New residential areas will be planned around the city of Amsterdam; the compact city policy will largely be abolished in order to provide attractive housing possibilities. As a result, the population of Amsterdam will largely increase. Also older living quarters will be renewed, so that also the quality of housing in these quarters will largely improve.

At the same time, there will be large scale expansions of business areas. The south of Amsterdam will become a flourishing office/services area, while the north (around the harbour) will become an important site for more industrial activities.

Mobility will be viewed as an important condition for accommodating economic growth and congestion will be coped with to the maximum extent. Environmental objectives on the other hand will receive a much lower priority: measures will only be introduced when they have no negative consequences for the local and regional economy. For example, the parking policy will aim at keeping the centre of the city 'accessible'. Economic traffic (urban goods transport and business traffic) will get priority, while commuting traffic will be discouraged: improved public transport will have to meet commuting demands.

At the national level road pricing will be introduced on highways and this will hold also for the highways around Amsterdam. The fares will however be low and only levied in rush hours. To meet the increasing mobility demand, the main road infrastructure around Amsterdam will largely be expanded and constructed largely subterranean in order to save expensive space (especially in the south of Amsterdam). However, mobility growth will be so large, that congestion will also be a major problem in the year 2015.

Public transport policy

A high quality public transport system will be regarded as a condition for stimulating economic growth and reducing congestion. Public transport will therefore be subsidized and high quality infrastructure will be constructed especially towards new business areas to stimulate economic growth. The national government will not fully support these investments, but the local authorities will be able to raise funds themselves. At the south of Amsterdam a second Central Station will be constructed, which will also be the station of the High Speed Trains towards France and Germany. Also underground and light rail connections will be expanded, e.g. to the harbour area in the northern part of the city.

Because the new residential areas will be built in a spatially diffuse way, it is not feasible to construct high quality infrastructure to these areas, because the traffic flows are too thin. Moreover, the people living here are mainly middle income groups, owning and using a private car.

The development of new service areas in Amsterdam-South will result in a shift from economic activities out of the centre. This will be reinforced by the increasing parking and accessibility problems in this area. The economic function of the centre will become more and more a shopping and 'fun' area (pubs, cinemas etc.). To stimulate these developments and to keep the city accessible car use will be discouraged, while Park & Ride areas will be built at the borders of the city. These parking areas are mainly constructed as subterranean facilities near the main nodes of the public transport system.

At the border of the city new shopping malls will be constructed which are well accessible by car; these developments will increase congestion at the border of the city.

The potential role of the electric car

The national and international policy will generate little initiatives to stimulate the use of electric cars. Therefore, no economies of scale will occur in the R & D and production of the electric car and the car will not become economically competitive with the conventional car. For example, fuel taxes will not be raised drastically.

Local authorities will also not have many incentives for stimulating the use of electric cars, because the environmental policy will not have much priority and the introduction will have no large impacts on economic developments. As a result, the electric car will not gain a large market share.

To a small extent, the electric car may be used as a feeder for the public transport system. A problem is however, that on long distances public transport will not be very attractive, so that the range of the electric car becomes a main problem.

Also in the urban goods distribution no central system (in which electric vans may operate) will be set up, so that also for goods transport the opportunities for electric cars are limited.

4.2 Sustainable Amsterdam

In this scenario all authority levels will aim at achieving sustainable economic growth. This implies that not only economic, but also the transport system will have to fulfil environmental quality conditions. At the local level environmental issues will play a vital role, while there is at the same time a strong European coordination (cf. the CPB European policy scenario). This results in the scores on the distinct axes as presented in Figure 4.
Next, this scenario will be elaborated in the same way as the previous one.

The national context

In this scenario it is assumed that there will be a large scale European coordination of environmental and transport policies. Therefore, measures will be taken at a European level; such measures will have no impact on the competitive position of countries and free rider behaviour will not be possible. This has certainly have positive impacts on the degrees of freedom for policy makers.

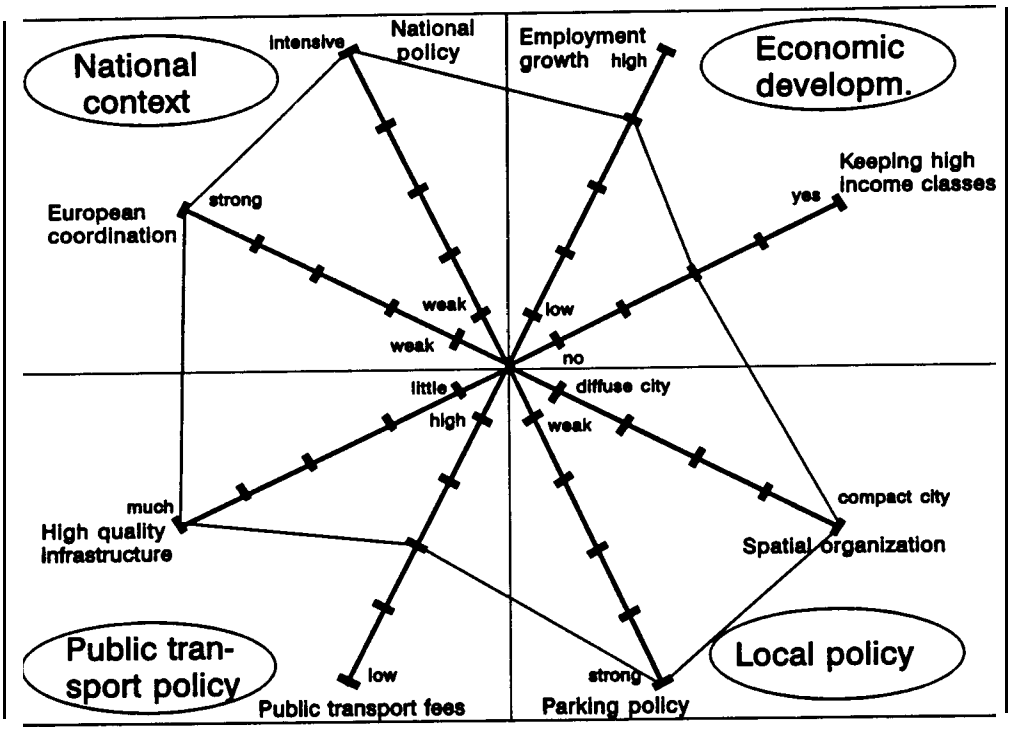

Figure 4 The scores in the scenario 'Sustainable Amsterdam'

The most important measures at the national and European level will be that NO_x emission standards will become more severe, fuel taxes will largely be raised, tax exemptions for business and goods transport will be abolished and a policy focusing on spatial concentration will be introduced. As a result, mobility levels of passenger transport will decrease, while energy use will even be lower. The impacts on goods transport will be smaller, however.

Local economic developments

The development of Schiphol airport of Amsterdam towards a European mainport will succeed, despite limitations due to noise annoyance standards. The airport will in the first place aim at attracting goods and business passengers, having the highest value added for the regional and national economy. Charters and transit traffic will be limited and/or shifted to other airports. In addition, the High Speed Train will become very successful, so that the market share of transport on distances up to 500 kilometres will become high at the expense of air transport. As a result, Schiphol's growth is less than possible, without having much impact on the local and regional economy. The emissions will also be lowered because of European standards for emissions and higher fuel prices. As a result, economic activities will grow rapidly.

The northern side of Amsterdam will attract many small scale industrial activities, with a high value added. A strict policy for pollution standards will be introduced: polluting activities will not be accepted. Especially, distribution and

assembly activities will take place here. The policy will give this area an environmental friendly image, which will attract new activities.

The south of Amsterdam will develop towards an international top office location, with an emphasis on business and financial services. This development will have clear positive impacts on the higher educated part of the population. This will also have a positive impact *on* the objective of keeping higher income classes in the city. However, the compact city policy will reduce the attractiveness of the city for these groups.

Local policy

At the local level the compact city will very strictly be implemented. No new large residential areas will be constructed after the ones planned already; at the same time, parks will be saved to keep the city attractive. Old living quarters will be renovated and upgraded, while also many buildings will be replaced and made much higher than they are now. Many new activities will be constructed as subterranean facilities, which holds e.g., for shopping malls, parking possibilities and infrastructure. The southern part of Amsterdam will become a densely built office area with skyscrapers, while also in the harbour area high buildings will be constructed which will be rented by several companies. In this way, a compact city will come into existence, in which also quite some housing possibilities for the higher and middle income classes will be found.

The policy at the international, national and local level wiil aim at reducing car transport. The most important measures at the national level are an extensive road pricing system and high fuel prices. In the city of Amsterdam a complementary cordon pricing system will be introduced: when a car enters a certain sector, a certain amount will automatically be paid. In this way, car driving will become very expensive, especially in the city and the densely populated areas around the centre.

Also urban parking policy will be very strict. In the centre, parking at the surface will largely be forbidden and parking is only possible in commercially exploited subterranean parking lots. In total, the number of parking places is largely reduced. Parking fees will be introduced all over the city now, although the fees are very low at the main nodes of the public transport system.

For goods transport, a central extra-urban goods distribution centre will be set up leading to a redistribution of commodity flows, while other freight transport will largely be forbidden all over the city.

Public transport policy

Car transport will become much more expensive making public transport more competitive, because of the national measures. The tariffs will be kept low by large scale subsidies. Large investments will occur in rail infrastructure. Both the southern and northern part of Amsterdam will be linked to high quality modes (underground; light rail), while also transport to other regional cities will drastically improve. In this way, a public transport system will be constructed with a region-wide coverage. Because of the national policy and investments, the train will become very attractive as a means of transport for longer distances.

The underlying network will drastically be changed. In the centre many conventional trams and buses will still be in operation, but many new initiatives will be taken to make this underlying network more efficient and profitable. Shared taxi systems will be set up, while there will also be more innovative bicycles which drive more efficiently and which can easily be parked at the main nodes of the public transport system. Another important innovation will be the extensive possibilities for renting bicycles, scooters and (electric) cars at public transport terminals for short and long periods. Another very important means of transport becomes the water. This capacity will be utilized to the maximum extent by public transport means like water taxis, which offer attractive and fast connections. Also new information technologies will be introduced to improve the quality of this underlying network of transport modes from and to the public transport system.

When these modes are not convenient for a certain trip, efficient 'call a car' systems will be set up. People can choose a type of car per trip: when it is a long distance one, a conventional car may be taken, while otherwise an electric car will be used.

This will give people many more possibilities to be flexible in choosing their transport mode, so that they can choose per trip for the most cheap and convenient alternative.

The role of the electric car

It may be clear that the role of the electric car will be large in this scenario. The electric car will largely be used as feeder for the high quality public transport system, which is most attractive and cheap for longer distances. Therefore, the limited range of such a car is not a main problem, which will even be reinforced by the compact spatial organization. Also the more collective ways of travelling to and from the nodes (e.g., by small buses and taxis) may largely be powered by electricity.

The use of electric cars will even be further stimulated because of the fuel price increases all over the European Union, which make these cars relatively cheap. The European coordination will also be important for the R & D and production of electric cars, which will result in large economies of scale.

When people use the 'call a car' systems, the use of an electric car will be cheaper than the rental of a conventional one. Therefore, conventional cars will only be used when the range of a trip is too large for an electric car.

Also in other fields the use of electric transport will increase. The central goods distribution system will largely use electric vans. The average distances to travel are relatively small and when necessary the vans can change batteries at the distribution centre. Also the transport over water will largely use electric engines. This will also result in a more extensive use of the necessary loading infrastructure, which will make the use of electricity even cheaper.

4.4 Pauperized Amsterdam

The previous scenarios were characterized by a strong positive economic development. In the scenario 'Pauperized Amsterdam' however, the local economy and employment will develop very negatively. At the same time, the national policy will aim at achieving a sustainable transport system, although there is little European coordination and agreement in this field (cf. the CPB national policy scenario). The resulting Spider model is presented in Figure 5.

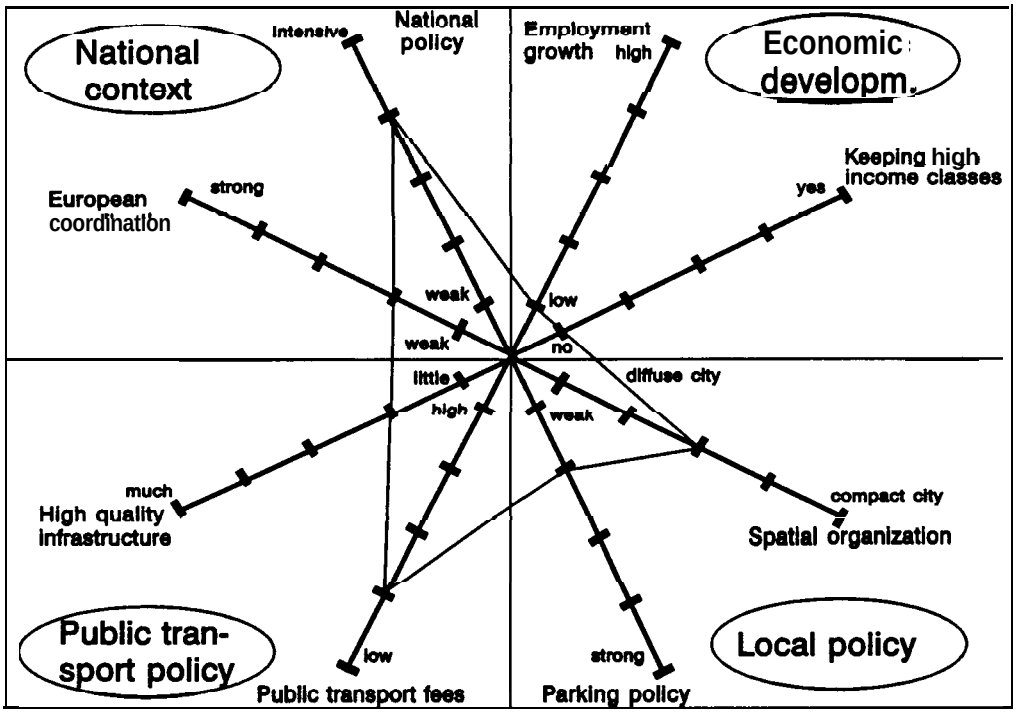

Figure 5 The scores in the scenario 'Pauperized Amsterdam'

National context

In the Netherlands there will be a large support for environmental measures; in other European countries this support will be much less, however. As a result, measures will not be coordinated in Europe, which will reduce the degrees of freedom when taking measures. This will hold especially for measures within competing sectors, in the first place goods transport. This scenario is therefore mainly oriented towards reducing passenger traffic (private cars). The most important measures will be a large rise in the taxes on fuels, the road pricing fees will be high (especially in the densely populated and congested Randstad), business traffic will be limited by means of tax policies and a policy aiming at spatial concentration will be introduced.

In conclusion, mobility growth will diminish significantly, which will result in much lower congestion levels and CO_2 emissions, although official national targets will not be achieved.

Local-economic developments

Amsterdam will not succeed in developing itself socially and economically, but will fall in a negative spiral. The economic base within Europe will shift to the south, so that the city will become more and more peripheral. People and economic activities shift towards Southern Europe, while Central-Eastern Europe will become increasingly competitive for industrial activities. The local economic policy will not be able to reverse these developments. At the same time, there are little funds available for new investments, so that e.g. congestion cannot be solved by investing in transport infrastructure.

Schiphol airport will not become a European mainport because of the increasing competitiveness of airports in other parts of Europe. Despite the construction of the High Speed Train, the growth of the airport will be very limited. The large scale investments in the airport will therefore result in large financial burdens for local and regional authorities, which will again result in lower funds available for other investments.

There will also occur an increasing competition between the North Sea harbours in North Western Europe. All harbours will heavily invest, but the negative economic developments will make these investments unprofitable. The harbour of Amsterdam will be one of the losers in this game, also because most attention and investments will be for Schiphol airport. Nevertheless, the large investments in the harbour will result in even larger financial burdens for the local government.

The financial sector will face increasing competition of Frankfurt and London (especially after the start of the European Monetary Union), and the business services will follow the general trend towards the south of the Netherlands and Europe. As a result, there will be little employment for the higher educated people, so that this group will also largely leave Amsterdam. But also for other groups, unemployment will increase because of the negative economic developments.

Local policy

Middle and higher income groups will largely leave the city because of the low employment possibilities. As a result, a negative spiral will occur marked by high unemployment, high crime levels, budgetary problems of the local authorities, etc. There will, for example, be little funds available for investments in housing and for upgrading deteriorating areas reinforcing the migration of higher income groups.

As mentioned above, also the development of Schiphol and the harbour will not succeed, despite the fact that much space will be reserved for these purposes. The same will hold for many office locations. As a result, many empty areas will come into existence around Amsterdam, becoming the symbol of the economic decline.

The national transport policy will result in much lower mobility growth, because of price increases of fuels and the road pricing systems. As a result, also mobility growth in the Amsterdam region will be lower, which will be reinforced by the negative population growth and economic developments. However,

supplementary local measures - like a more strict parking policy - will not be implemented, because it is feared that these will result in even worse economic developments. Also a central goods distribution system will not be introduced. Despite this, the pressure on space and the environment will be reduced.

Public transport policy

There will be little funds available for investments in the public transport system, but there will also be lower needs because of the negative economic developments and the limited population growth. Therefore, investments in high quality infrastructure will largely be abolished. Nevertheless, the public transport system will become increasingly important for the poorer population because of the higher prices for car transport. Also in the underlying networks, less funds will be available: the current bus and tram system will still largely be in operation despite some budget cuts.

The national government will subsidize the fares to a large extent. Because of the lower fares, the reduced car ownership, the higher prices for car use and the limited carrying capacity of the population, the modal share of the public transport system will increase despite the low investments in this sector.

The role of the electric car

At the national level several measures will be taken to reduce car use. The rise in fuel prices will make the use of electric cars more attractive, but also lower road pricing fees may be introduced to stimulate electric car use.

Local developments however, will not stimulate the use of electric cars. The population will largely not have the financial sources to buy to a large extent electric cars. The local policy will not give much attention to electric cars, because most attention will be paid to reducing economic decline.

In conclusion, the national policy may include incentives for an increased use of the electric car; the local policy and developments, however, will keep the role of the electric car limited.

5.5 Lonely Amsterdam

In this scenario, there will be little support for measures at the national level (limited social support scenario). The local policy will be characterized by a strong policy focused on a sustainable development, while the local economy will develop positively. As a result, Amsterdam tries to achieve an environmentally sustainable transport system, without much support from the national government. The resulting scenario as depicted in the Spider model is presented in Figure 6.

The national context

At the national level there will be little strict transport policy measures, while also at the European level no coordination occurs. Only measures will be taken, which will not cause much resistance in society, and thus will not largely affect the mobility pattern of the population. The most important measures,

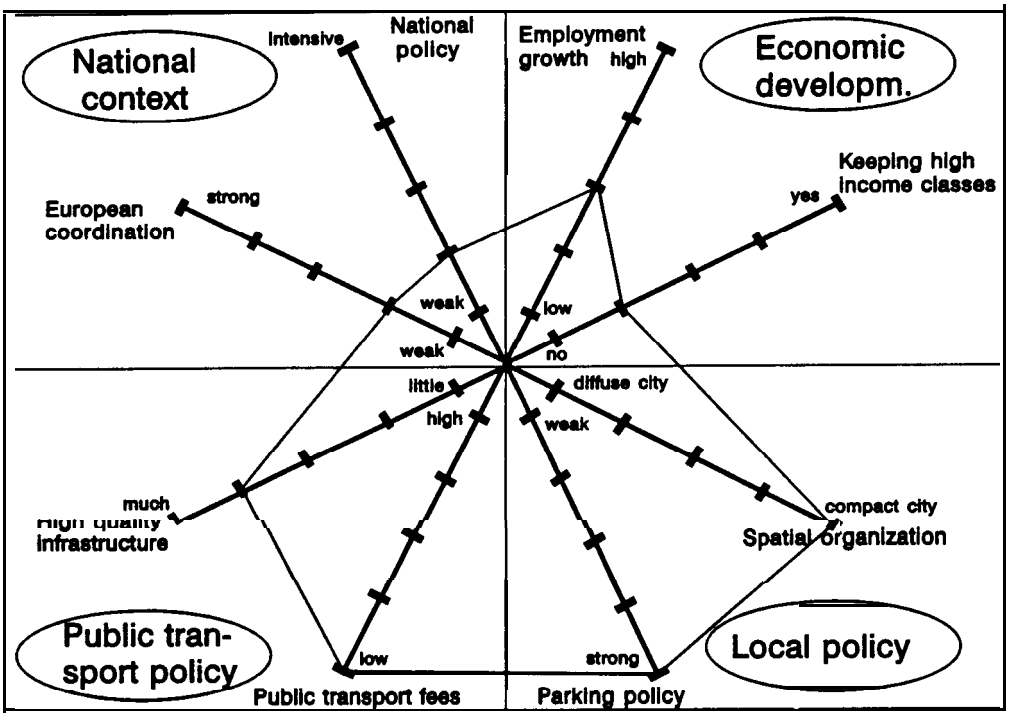

Figure 6 Scores in the scenario 'Lonely Amsterdam'

which will be taken are: a strong reduction of public transport fares, stimulating car pooling and car sharing projects and tax cuts for energy efficient cars.

These measures will only have a limited impact on the achievement of policy objectives like the reduction of mobility growth and of gas emissions. The congestion levels will not be reduced either.

Local economic developments

The airport of Amsterdam, Schiphol, will at first continue to grow towards an international mainport, also because the national government will support this option with investments and less constraints. The local authorities, however, will try to reduce the growth (and annoyance) of the airport to some extent. Therefore, expansions of the airport will not be allowed and a second airport will be constructed in the sea. As a result, the positive impact on the local economy will be reduced to some extent, but the annoyance (noise, smell) and the pressure on space will also be reduced. The growth of Schiphol airport will also be limited by means of the High Speed Train construction, which will be able to successfully compete with air transport because of the subsidies given by the national government.

The municipality will start an active acquisition and stimulation policy for attracting environmental-friendly, small-scale and labour-intensive industrial activities with a high value added. These will largely be assemblage and distribution activities, making use of the supply via the harbour and eventually via

Schiphol. At the same time, very strict environmental standards will be introduced, which result in a shift of more polluting activities out of the Amsterdam region.

A second target of the local authorities will be the development of a top office location in the southern part of Amsterdam, with a strong emphasis on business and financial services. The strict parking policy however, will have a negative impact on economic developments here, while the compact city policy will result in an upward pressure on prices. Therefore, this policy will not be entirely successful. Despite this, a lot of new employment will be created here, especially for the higher educated part of the population. In addition, also employment for other groups will increase.

Local policy

One of the aims will be to make the city attractive for higher income groups. At the same time, however, environmental objectives should be achieved, which may sometimes conflict with other objectives. The compact policy will be introduced strictly and large expansions of the city will not take place. As a result, the possibilities for building attractive houses are limited. In the surroundings of Amsterdam, attractive housing will be available, because here less strict measures will be introduced. As a result, a large part of the population will leave the city, also resulting in increased commuter traffic and congestion around the city of Amsterdam. Also expansions of Schiphol, the harbour and Amsterdam-South will be kept limited by means of constructing high buildings and using subterranean space.

Despite the fact that the national transport policy will not be supportive, the local authorities will introduce a series of measures. This will be possible, because social support for measures will be larger than in the Netherlands as a whole. This is caused by the large negative impacts of car transport in a big city, while the Amsterdam population traditionally has a positive attitude towards environmental and transport measures.

Especially in the centre of the city, car transport will be reduced by means of a system of cordon pricing with high tariffs and a strict parking policy. At the same time public transport will largely be improved, so that the economic function of the centre will be maintained. A central goods distribution centre will also be set up, using electric vans of which the batteries can be replaced easily.

The public transport policy

In addition to a strong reduction of public transport fares at the national level, Park & Ride systems will be introduced as well as a system of cordon pricing. This will result in a strong reduction of car use in the city. As a consequence of the positive economic developments, the local government will have many funds available for investments in residential areas, public transport infrastructure and business areas. High quality public transport infrastructure will be constructed in the whole region, and the underlying network will be adapted by means of shared taxis, rental possibilities (for cars, bicycles, etc.), ‘call a car’ systems and transport over water.

The role of the electric car

The electric car will play a role, although not all conditions will be positive to favour its introduction. A large share of the high income groups - being the main market for electric cars - will leave the city. At the national level ownership taxes will be low for electric cars and electricity will be less taxed than other fuels. Also in 'call a car' systems, electric cars can be used when the trip is not too long. The electric car will mostly used, however, as 'feeder' for the public transport system.

The local policy will stimulate the use of electricity. Shared and normal taxis will be powered by electricity, while also transport over water will use electricity in the transport system and electric vans will be used for the goods distribution. This will result in quite a large market, and therefore investments in the loading infrastructure can be shared among many users.

5 Strategic Conclusions

The electric car does not receive much attention in current local policy debates. However, the substitution of conventional cars by electric cars may largely contribute to environmental policy objectives.

It appears that there are many factors which influence the successful introduction of electric cars. A first conclusion to be drawn however, is that flanking policies are necessary for a successful introduction. At the European level R & D can be stimulated, while the competitive position of the electric car can be improved by raising fossil fuel taxes or by levying a CO_2 tax. Also many measures can be taken most efficiently at the European level, in order to avoid free rider behaviour of individual member states. National policies will influence the success of electric cars largely. Ownership taxes, road pricing systems, public transport fares and fuel taxes will have a large impact on electric cars vis-a-vis the conventional car; moreover, the national government is the most important investor in public transport infrastructure.

Nevertheless, local policy can have a large impact on a successful introduction. A positive local economic development seems a necessary condition; otherwise, there are little funds available for necessary investments, the policy will focus on economic issues and there will be no market for electric cars.

An attractive option may be adaptations of the underlying public transport network for trips from and to main nodes of the public transport system. Shared taxis, improved bicycles, transport over water and improved car rental possibilities may be important in this respect. One should be aware however that the accessibility of especially the city centre may be reduced, which may have negative impacts on the urban economic development. The same would hold, when Amsterdam introduces strict measures and the surroundings of Amsterdam do not.

The role of the electric car is mostly that of 'feeder' of high quality public transport systems and as rental possibility in 'call a car' systems. Electricity may also be used in central goods distribution and transport over water. In this way

investments in the charging infrastructure can be spread over more users, which may make these more profitable.

It can be concluded that - when there are sufficient flanking policies - the electric car may significantly contribute to a reduction of external costs caused by transport in cities.

References

Bruinsma, F.R., S.A. Rienstra and P. Rietveld, 1997, Success and Failure Factors of Developing International Top Office Locations; A Case Study for Amsterdam South, research paper in progress, Dept. of Spatial Economics, Free University, Amsterdam.

CPB (Central Planning Bureau), 1996, *Economie en Milieu: Op Zoek naar Duurzaamheid*, SDU, The Hague.

DeLuchi, M.A., 1993, Greenhouse-Gas Emissions from the Use of New Fuels for Transportation and Electricity, ***Transportation Research,*** vol. 27A, no. 3, pp. 207-216.

DeLuchi, M.A., Q. Wang and D. Sparling, 1989, Electric Vehicles: Performance, Life-Cycle Costs and Recharging Requirements, ***Transportation Research,*** vol. 23A, no. 3, pp. 255-278.

European Commission, 1996, ***New Market Oriented Transport Systems,*** Transport Research APAS Urban Transport, DG-VII, Luxembourg.

Gemeenteblud , 1993, Amsterdam naar 2005, bijlage H, Amsterdam.

EZ (municipal dept. of Economic Affairs), 1996, ***Op Weg naar 2015; Vier Toekomstscenario's voor de Amsterdamse Regio,*** Amsterdam.

Milieudienst (municipal dept. of Environmental Affairs), 1994, *Integrale* ***Milieuvisie Amsterdam*** *1994-2015*, Amsterdam.

Nijkamp, P., and S.A. Rienstra, 1996, Sustainable Transport in a Compact City, in: Jenks, M., E. Burton and K. Williams (eds.), ***Compact Cities and Sustainability: An Introduction,*** E & FN Spon, London, pp. 190-199.

Nijkamp, P., H. Ouwersloot and S.A. Rienstra, 1997a, Sustainable Urban Transport Systems; An Expert-Based Strategic Scenario Approach, ***Urban Studies,*** vol. 34, no. 4 (forthcoming).

Nijkamp, P., S.A. Rienstra and J.M. Vleugel, 1997b, ***Transportation Planning and the Future,*** John Wiley, Chicester (forthcoming).

Novem (Netherlands Institute for Energy and the Environment), 1992, ***Elektrische Auto's in het Perspectiefvan de Milieu- en Energieproblematiek,*** Apeldoom.

0 +S/DRO, 1993, ***Bevolkingsprojectie voor het ROA-gebied tot 2015,*** Amsterdam.

0 + S/DRO, ***1994, Amsterdam; Bevolkingsprojecties tot*** 2015; *Gehele Stad*, vol. 8, Amsterdam.

OECD (Organization for Economic Cooperation and Development), 1992, ***The Urban Electric Vehicle,*** Paris.

Pharoah, T. and D. Apel, 1995, *Transport* ***Concepts in European Cities,*** Avebury, Aldershot.

Quandt, C.O., 1995, Manufacturing the Electric Vehicle: Window of Technological Opportunity for Southern California, ***Environmental and Planning A,*** vol. 27, pp. 835-862.

Rienstra, S.A., 1996, ***Amsterdam en Elektrische Auto 's: Een Scenario-Analyse,*** report for Energy Northwest Amsterdam NV, Dept. of Spatial Economics, Free University, Amsterdam.

Rienstra, S.A., and P. Nijkamp, 1997, From the Expected to the Desired Future of Passenger Transport; A Stakeholder Approach, in: Requier-Desjardins, D., C. Spash and J. van der Straaten, ***Environmental Policies and Societal Aims,*** Kluwer, Dordrecht (forthcoming).

ROA (Regional Coordination Authority), 1993, ***Regionaal*** *Verkeers-* ***en Vervoersplan,*** Amsterdam.

Tweede Kamer (Dutch parliament), 1990, ***Tweede Structuurschema Verkeer en*** *Vervoer*, deel D, regeringsbeslissing, no. 20 922, SDU, The Hague.